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REPORT

on

PRELIMINARY BIOLOGICAL SURVEYS OF THE ST. LAWRENCE RIVER

1966 - 1967

December, 1968

ONTARIO WATER RESOURCES COMMISSION

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Report on preliminary biological
surveys of the St. Lawrence
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Report on

PRELIMINARY BIOLOGICAL SURVEYS
OF THE ST. LAWRENCE RIVER
1966 - 1967

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December, 1968.

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SUMMARY AND CONCLUSIONS

Within the international section of the St. Lawrence River, bottom fauna communities generally indicated water of good quality. Local surveys below major waste discharges from Ontario municipalities demonstrated significant contamination of the river at Kingston, Brockville, Cardinal and Cornwall. The extent of river affected in each case was limited to near-shore waters. Significant impairment of river water from treated sanitary and industrial wastes and periodic overflows of untreated municipal wastes at other specific locations was not evident.

The results of bottom fauna surveys to date have defined, in a general way, the degree and extent of pollutional effects and have provided sufficient background data for future comparisons of trends in the overall quality of the river. Further local surveys will be required to examine water quality conditions at Brockville and Maitland in greater detail and to assess effects of specific waste sources at Cornwall.

Observations of aquatic vegetation have provided preliminary information on relative abundance, predominant species and existing or portential nuisance conditions. As a general rule, abundance and extent of growths were determined largely by physical factors, particularly depths and substrate types. Cladophora was generally distributed throughout all reaches of the river. Production

per unit area was greatest in all cases below sources of municipal wastes where it is possible that local nuisance problems may develop. Excessive production of macrophyte-vegetation in upper Lake St. Francis has led to serious adverse effects on recreational and other uses of these waters. The problem of nutrient inputs to the St. Lawrence River has to be regarded as the most serious pollution threat, considering the widespread effects on recreational uses created by increased production of algae and aquatic plants.

The results of this survey have indicated that sufficient quantities of good quality water are available for adequate dilution of waste waters, for water supplies and for other uses at the present time. The overall quality of the river is largely determined by that of Lake Ontario and is not appreciably altered by existing waste discharges, with the probable exception of nutrient inputs.

Recommendations

- 1) Further reductions of sanitary and industrial waste discharges must be achieved to protect the confined waters of Kingston harbour and improved effluent quality is required at the St. Lawrence Starch Company at Maitland.
- 2) Additional surveys should be undertaken to delineate the localized impact of specific waste discharges at Brockville, Maitland and Cornwall.

- 3) The maximum elimination of plant nutrients (nitrogen and phosphorus) from sanitary and industrial waste discharges, is essential and, unless local circumstances dictate to the contrary, should be given priority over solids and BOD removal.

PRELIMINARY BIOLOGICAL SURVEYS OF THE
ST. LAWRENCE RIVER 1966-1967

INTRODUCTION

Previous reports published by the Ontario Water Resources Commission (OWRC) have clearly defined the sources and character of domestic and industrial waste discharges to the St. Lawrence River. These studies have indicated values for chemical and bacterial parameters in excess of OWRC objectives for discharge to surface waters. Also, water quality investigations, while failing to demonstrate physical or chemical impairment of water quality, have indicated varying degrees of bacterial contamination related to domestic waste discharges.

In an attempt to further define the degree and extent of pollution in the St. Lawrence River and to determine the effect of pollution on river biota, a preliminary survey of biological conditions of the river was carried out during the summers of 1966 and 1967. A further objective of the survey was to establish the necessary background data with which future trends in water quality may be compared through continuing surveillance studies. Further to the pollution abatement program of the OWRC, the work undertaken was compatible with the terms of reference outlined by the International Joint Commission in its directive of 1964.

DESCRIPTION OF THE RIVER

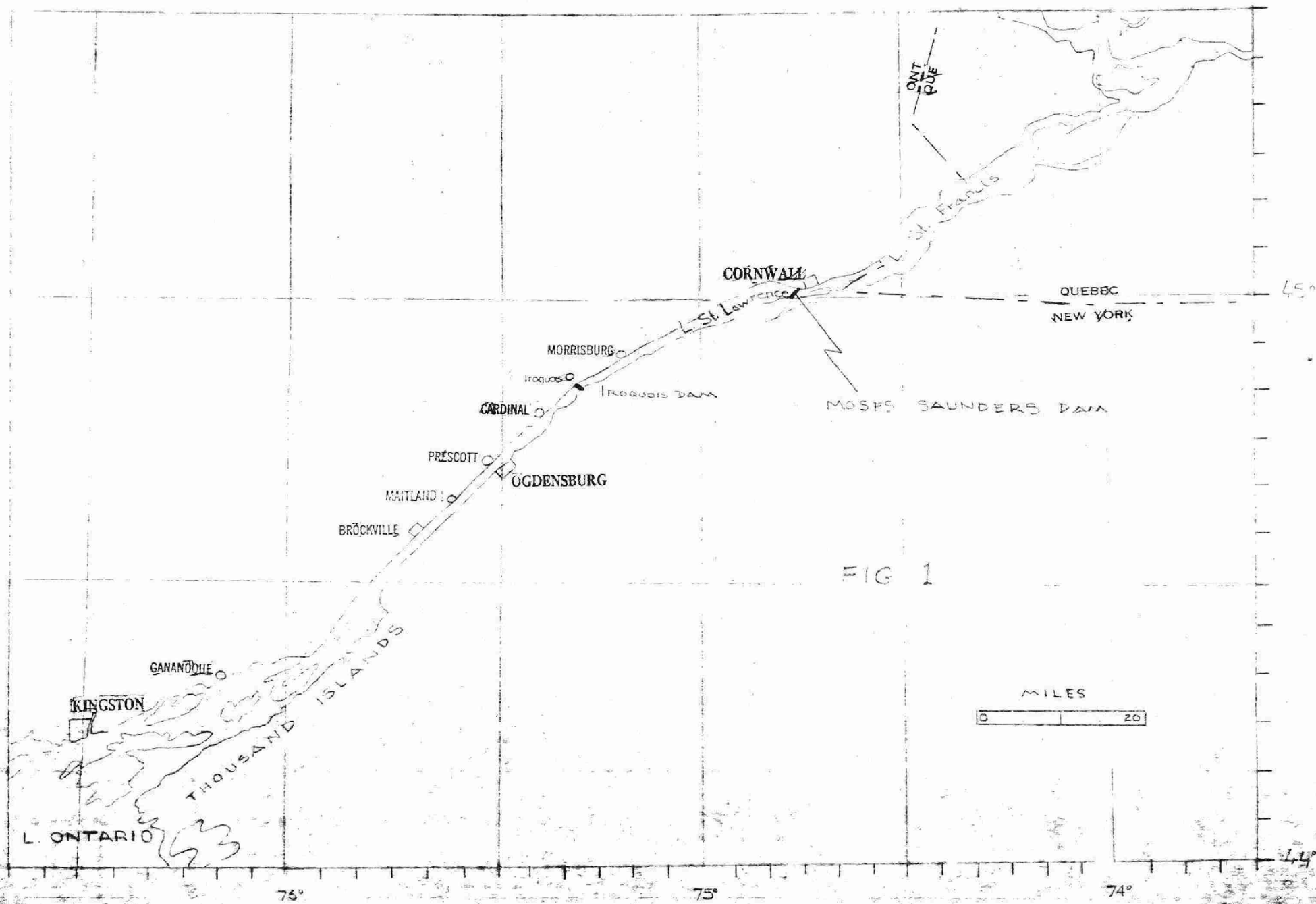
The St. Lawrence River carries the discharge of waters from the entire Great Lakes drainage system, an area of 296,000 square miles upstream of the Moses-Saunders power dam at Cornwall. Discharge rates recorded at Iroquois up to 1958 and at the Moses-Saunders dam following completion of the 'Seaway' development have been published by the Department of Energy, Mines and Resources (formerly Department of Northern Affairs and National Resources). The mean discharge for the 95-year period up to 1958 was 240,700 cubic feet per second and for the period October, 1959 to September, 1966 was 219,600 cfs, with a range in the mean daily maximum and minimum discharge between 237,000 cfs and 164,000 cfs. Over the past fourteen years, there has been a gradual decline in the mean annual discharge from a high of 276,000 cfs, October, 1951 to September, 1952, to a low of 201,000 cfs October, 1964 to September, 1965.

The development of the 'St. Lawrence Seaway' during the period of 1954 to 1958, vastly altered morphometric and hydrological features of the river upstream of Cornwall. Construction of the Moses-Saunders power dam at Cornwall and the Long Sault and Iroquois control dams provided for the regulation of water levels of Lake Ontario and the St. Lawrence River downstream to Cornwall. The resulting formation of Lake St. Lawrence eliminated the Long Sault rapids and inundated extensive areas of land as far upstream as Iroquois. Below Cornwall, water levels of

Lake St. Francis have been regulated by the power dam and associated control works at Beauharnois, Quebec, for approximately the past fifty years.

Throughout most of the river, depth profiles, current patterns and velocities and substrate types are extremely variable. This applies particularly to the region of the Thousand Islands, upper Lake St. Francis and much of Lake St. Lawrence. Typically, substrates consist of deep deposits of silt and/or fine organic matter in littoral regions with shallow profiles, giving way to sand, gravel and boulders or bedrock at greater depths. Notable exceptions include the shallower, recently flooded areas of Lake St. Lawrence where the bottom consists chiefly of woody detritus with little evidence of accumulations of finer deposits, and the exposed shorelines at Kingston where appreciable sediment deposits occur only at depths greater than 15 to 20 feet.

The St. Lawrence River supports a multiplicity of uses important to federal, provincial and local economies. These include generation of hydro-electric power, commercial shipping, domestic and industrial water supplies, waste-water assimilation, commercial fisheries and a variety of recreational pursuits. With respect to the latter, summer residency, boating, swimming, angling and sight-seeing are of importance.



METHODS

Biological Parameters

Under natural conditions aquatic plant and animal communities consist of a variety of forms existing in a relatively balanced state. Abnormal changes in water quality favours a predominance of forms capable of adapting to these changes. This imbalance of biological communities usually adversely affects the amenities and general usefulness of a watercourse. Biological data, therefore, are useful in assessing the degree of water quality impairment and are of practical value in interpreting polluttional effects on water uses.

In the present study emphasis is placed on communities of bottom fauna and aquatic vegetation (rooted aquatics and filamentous benthic algae). Bottom fauna communities are particularly useful as indicators of water quality for several reasons. These organisms are relatively restricted to one locality in the river; they are readily sampled and identified and are sensitive to toxic and organic pollution. Because of a relatively long life cycle, usually a year, benthic invertebrates reflect adverse conditions, even of short duration, over a considerable period prior to the survey. In addition, they form an important source of food for many species of fish. While aquatic vegetation is essential in providing food and cover for many other forms of aquatic life, excessive production induced by increased levels of nutrients from domestic and some industrial wastes, may seriously interfere with recreational pursuits, quality of water supplies and aesthetic qualities of the watercourse.

In addition to these parameters, limited sampling of phytoplankton populations was carried out to provide a comparative assessment of Lake St. Lawrence and Lake St. Francis. Data obtained from an already established monitoring program, which includes monthly samples from water treatment plants at Kingston, Brockville and Cornwall, will provide information on long-term changes in phytoplankton production and effects on the quality of water supplies. Coliform densities were determined to indicate the presence or absence of contamination by sanitary wastes. Physical-chemical data are complementary to biological data, providing a basis for interpreting observed changes in biological communities. Several parameters were sampled and are listed below under Field and Laboratory Methods.

Scope of Survey

Survey work was carried out from Kingston to the Ontario-Quebec boundary on the north shore of Lake St. Francis (Figure 1). Within this portion of the river several areas were selected for more intensive studies of local conditions in the vicinities of sanitary and industrial waste discharges from the following Ontario municipalities:

Cornwall (including Lake St. Lawrence, Cornwall narrows
and Lake St. Francis)
Morrisburg
Iroquois
Cardinal
Prescott
Maitland
Brockville
Kingston

(Selection of areas for intensive study was based on previous publications indicating discharges in excess of OWRC objectives or insufficient progress in waste control programs.) In addition to these local surveys, biological sampling was carried out more extensively to examine possible downstream variations in water quality and to provide background data for the monitoring of water quality trends in the future.

Field work covering the Cornwall area and including Lake St. Lawrence and Lake St. Francis was carried out between August 16 and September 14, 1966. Surveys in the upper portion of the river were completed during the period June 6 to July 8, 1967.

Location of Stations

The distribution of survey stations was based on the following considerations:

- 1) For purposes of obtaining control data, stations were selected in areas outside the influence of pollution sources (generally upstream).
- 2) Strength and volume of wastes and current direction and velocity were recognized in selecting stations below pollution sources. The large dilution capacity of the river has been demonstrated by previous chemical results. Consequently, sampling distance below pollution sources was kept minimal.
- 3) The complexity of bottom types, current patterns and unevenness of depth contours, typical of most sections of the river, placed definite limitations on the

distribution of sampling sites selected for bottom fauna analysis. Stations were selected to minimize variability in the data due to physical environmental factors so that changes in communities due to alterations in chemical characteristics could be evaluated with a minimum amount of sampling. Alterations of the physical environment related to Seaway construction and operation (recent flooding and disturbance of bottom deposits by shipping and dredging) further complicated evaluation of pollutional effects.

A total of 79 stations were located in Lake St. Lawrence, the Cornwall Narrows and Lake St. Francis (Figure 10). Of these, 26 stations were sampled intensively whereas the remaining 53 provided more extensive coverage of these waters. The former were designated by a capital letter starting at station A in Lake St. Lawrence and proceeding downstream to station R in Lake St. Francis. (Stations on a common transect were numbered, e.g. A1, A2, A3) Other stations were designated numerically.

The distribution of stations within local study areas from Kingston to Morrisburg are shown in Figures 1 through 9. Stations were designated numerically and prefixed by an abbreviation of the adjacent municipality. In some cases more than one sampling site was selected at a station. These were designated a, b, c etc., in consecutive order proceeding offshore unless otherwise indicated.

Five transects, A-E, were located at intervals between Kingston and Lake St. Lawrence (Figure 11). On each transect, three stations were located extending across the river in depths of 20-30 feet (Ontario side), 50-90 feet (mid-channel) and 20-30 feet (New York side).

All stations were located in the field by triangulation using permanent land marks wherever possible or navigational aids and were plotted on navigational charts. A list of the stations used in this survey and their locations is provided in Appendix B.

Field and Laboratory Methods

Bottom Fauna

From 1 to 5 samples of bottom sediments were collected at each station using a 9x9 inch Peterson dredge for the 1966 work and a Ponar dredge in 1967. Sediments were washed through a pail screen (24 meshes per inch; 0.65 mm openings) in the field. Organisms and coarse detritus were transferred to plastic bags for further sorting at field headquarters. Collections were initially preserved in 95% ethanol for temporary storage. Specimens were later identified and enumerated at the laboratory, transferred to 70% ethanol and placed in the permanent collections of the Biology Branch (items 66B869 to 1052 and 67B1174 to 1473). Observations of substrate type, depths, temperature profiles, current velocity and benthic vegetation were noted in the field to aid the interpretation of bottom fauna distribution.

Sediments

Bottom sediments from selected stations were retained for a more detailed examination of physical properties and for analysis of various components of waste discharges. A sample sufficient to fill a 4-oz. jar was taken from the surface (to a depth of approximately one inch) of undisturbed sediments at the time bottom fauna collections were made. Composites were prepared where more than one dredge sample was obtained. Samples were immediately air-dried at room temperature. To date, determinations of ignition loss, zinc and ether solubles have been made only on samples taken at selected stations within and below the Cornwall area.

Plankton

Plankton samples were taken on one occasion during September, 1966, at a total of 24 stations, primarily those selected for intensive study, in Lake St. Lawrence, Cornwall Narrows and Lake St. Francis. Forty-ounce samples of surface water, and in some instances bottom water for comparative purposes, were collected using a Kemmerer depth sampler and preserved with 36 millilitres of mercuric chloride. Phytoplankton was identified to generic level and quantities expressed in areal standard units (a.s.u.) per millilitre. Zooplankton was classified generally and relative quantities noted.

Other aquatic vegetation

During August, 1966 and June 26-28, 1967, surveys were made of the distribution, general abundance

LEGEND FOR ALL FIGURES IN THIS REPORT

BOTTOM FAUNA SAMPLING SITES - Indicating number of samples

○	1
⊙	2
⊕	4
⊗	>4

SCALE

0 2000 feet (unless otherwise indicated)

OUTFALLS

⌈—	municipal sewage treatment plant
●—	industrial waste
→	untreated municipal wastes
---	municipal boundary

and species composition of aquatic vegetation (rooted aquatics and filamentous algae) along most of the Ontario shoreline. Observations were made during periods of clear weather and calm water permitting observations from the surface to depths of from 10 to 15 feet. In addition, information on previous trends in aquatic plant production and the effect of existing production levels on aesthetic and recreational values of the river, was obtained through informal interviews with resort and marina operators, summer residents, anglers and commercial fishermen.

Water Chemistry

Determinations of BOD, total, suspended and dissolved solids, pH, hardness, total phosphorus and ammonia, Kjeldahl, nitrite and nitrate nitrogens were performed in the laboratory on bottom water samples collected at each station. Dissolved oxygen levels of bottom water at selected stations were determined in the field by the azide modification of the Winkler method. Tests were performed during daytime and nighttime periods to describe daily maximum and minimum levels.

RESULTS AND CONCLUSIONS

The results of chemical and bacteriological sampling below waste sources, in most cases, did not reveal values in excess of Commission objectives for surface waters. Where significant alterations in water quality were indicated, data are presented along with the biological results.

Bottom Fauna

Results of the bottom fauna survey are provided in the following sections dealing with conditions observed in local surveys of municipal and industrial waste discharges and at transect stations located more extensively throughout the section of river under study. Within each section a brief summary of waste disposal practises and status of treatment facilities is provided, bottom faunal communities are described and conclusions are drawn with respect to effects of pollution sources on water quality and benthos. A tabulation of bottom fauna collections is provided in Appendix A.

Kingston

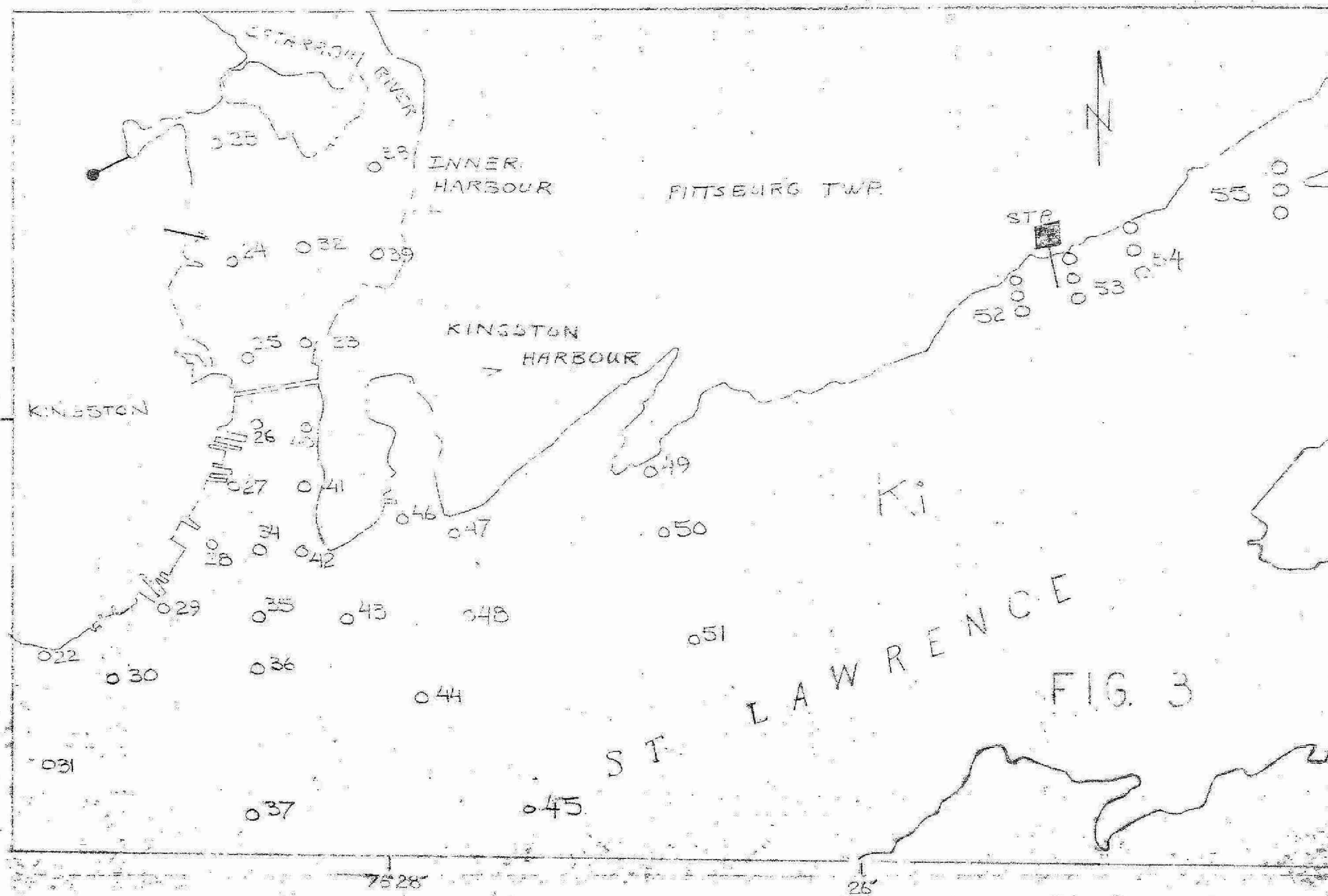
The city of Kingston is located in Kingston Township at the confluence of the Cataraqui River and the St. Lawrence River. The city is bounded on the east by the Cataraqui River which forms the inner Kingston harbour and a portion of the outer harbour. The westerly portion of the city is drained by the Cataraqui Creek which discharges to the Cataraqui Bay of the St. Lawrence River situated just west of the city.

A primary treatment plant, with a design capacity of 9.0 mgd, is located on the shore of the St. Lawrence River in Pittsburg Township approximately three miles east of Kingston. The plant receives sanitary wastes from a population of 60,000 and wastes from most industries in Kingston. The primary effluent is chlorinated and discharged to the St. Lawrence River through a 600-foot outfall sewer terminating in

approximately 42 feet of water. The plant is presently operating at close to capacity and experiences frequent hydraulic overloading due, in part, to combined sanitary and storm sewers. Overflow facilities are provided at five sewage pumping stations and at a number of other points through storm sewer outfalls resulting in periodic discharges of untreated municipal wastes to surface waters of Cataraqui Creek, Cataraqui River and the St. Lawrence River.

Major quantities of industrial wastes are discharged to surface waters from the Aluminum Company of Canada, Limited and Du Pont of Canada Limited (Kingston Works). The former, engaged in the production of aluminum sheet and foil, discharges significant quantities of BOD, suspended solids, ether solubles and aluminum to Cataraqui Creek; production of nylon thread at the Du Pont plant results in a waste discharge of approximately 7.5 mgd to Cataraqui Bay containing titanium oxide and phenols. The A. Davis and Son Limited tannery discharged a volume of 0.2 mgd containing high levels of BOD, suspended solids, ether solubles, sulphides, nitrogen and chromium to the Cataraqui River (inner harbour) prior to December, 1966, at which time these flows were directed to the municipal sewage system.

The biological survey of water quality within the Kingston area covered most of the river fronting on Kingston and the portion of Pittsburg Township in the vicinity of the Kingston sewage treatment plant, as well as Cataraqui Bay in Kingston Township and the lower portion of the Cataraqui River. Bottom fauna was collected at a total of 66 sampling sites (Figures 2 and 3).



At stations 2 and 3 (control) and stations 12 to 21, communities were generally diverse, containing an average of 10 taxa per station with a range of from seven to 13 taxa. No appreciable variations were observed in community structure that could be attributed to variations in water quality. However, within Cataraqui Bay, which received contaminated flows from Cataraqui Creek and Du Pont waste discharges, diversity within bottom faunal communities was somewhat restricted. The mean number of taxa observed per station was seven with a range of from two at station 7 to 13 at station 10. Station 5, located at the mouth of the creek, yielded eight taxa including the mayfly Caenis sp. and amphipods Gammarus spp., both relatively intolerant of organic pollution. Flows from the creek probably have little detrimental effect on the water quality of the bay with the exception of elevated turbidity levels locally at the mouth of the creek as indicated by low secchi disc readings and reduced abundance of benthos. The most restricted fauna in the bay occurred at station 7 where only two specimens of midge larvae, representing two genera, were obtained. This result was indicative of possible toxic effects of Du Pont waste discharges. Under conditions of favourable water quality, the shallow depths and general distribution and abundance of macrophytes throughout the bay would provide an environment suitable for a wide variety of organisms in excess of what might be expected to occur at deeper stations in the open portion of the river. The reduced number of taxa at stations within the bay suggested light to moderate impairment of these waters.

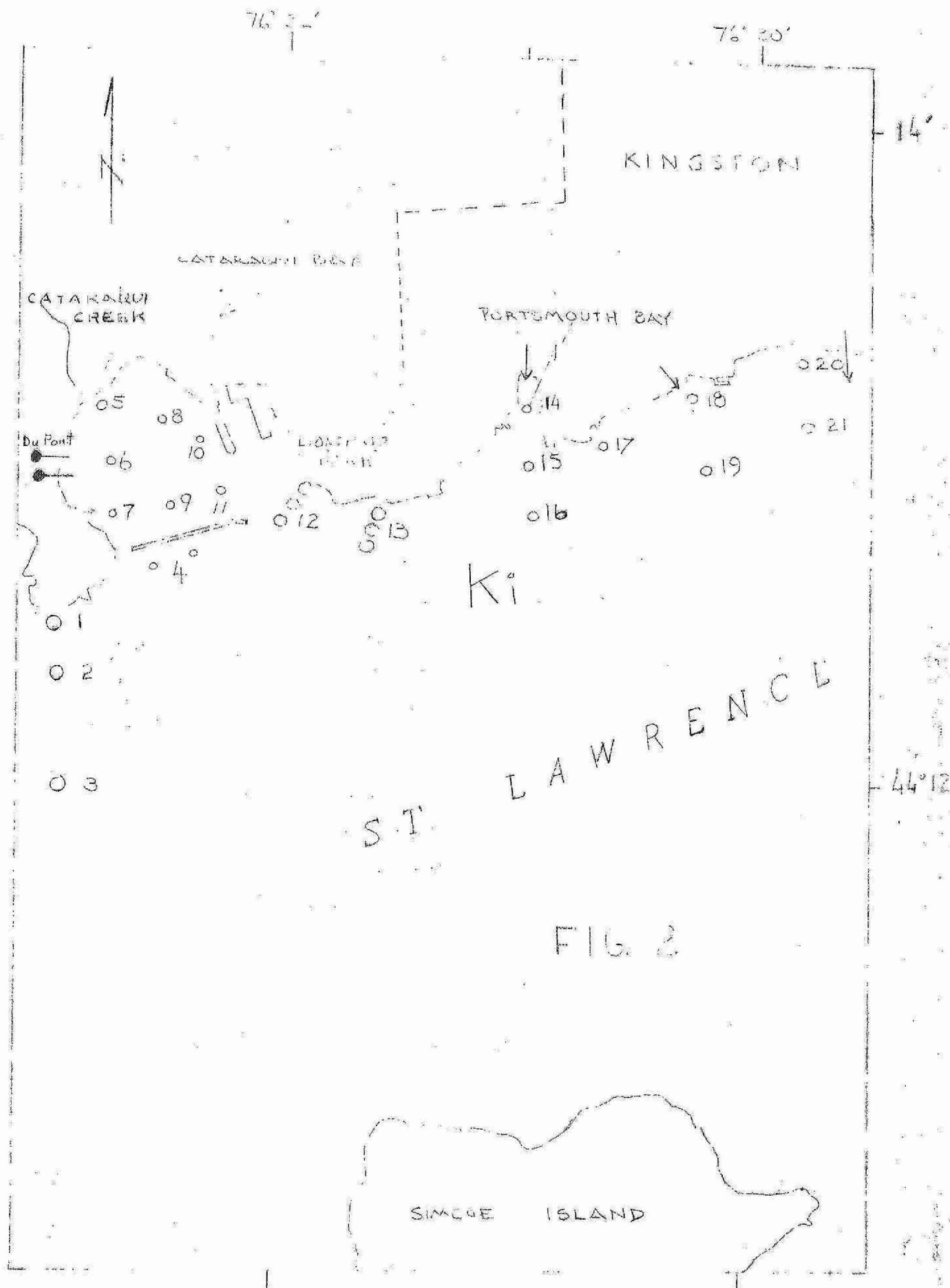
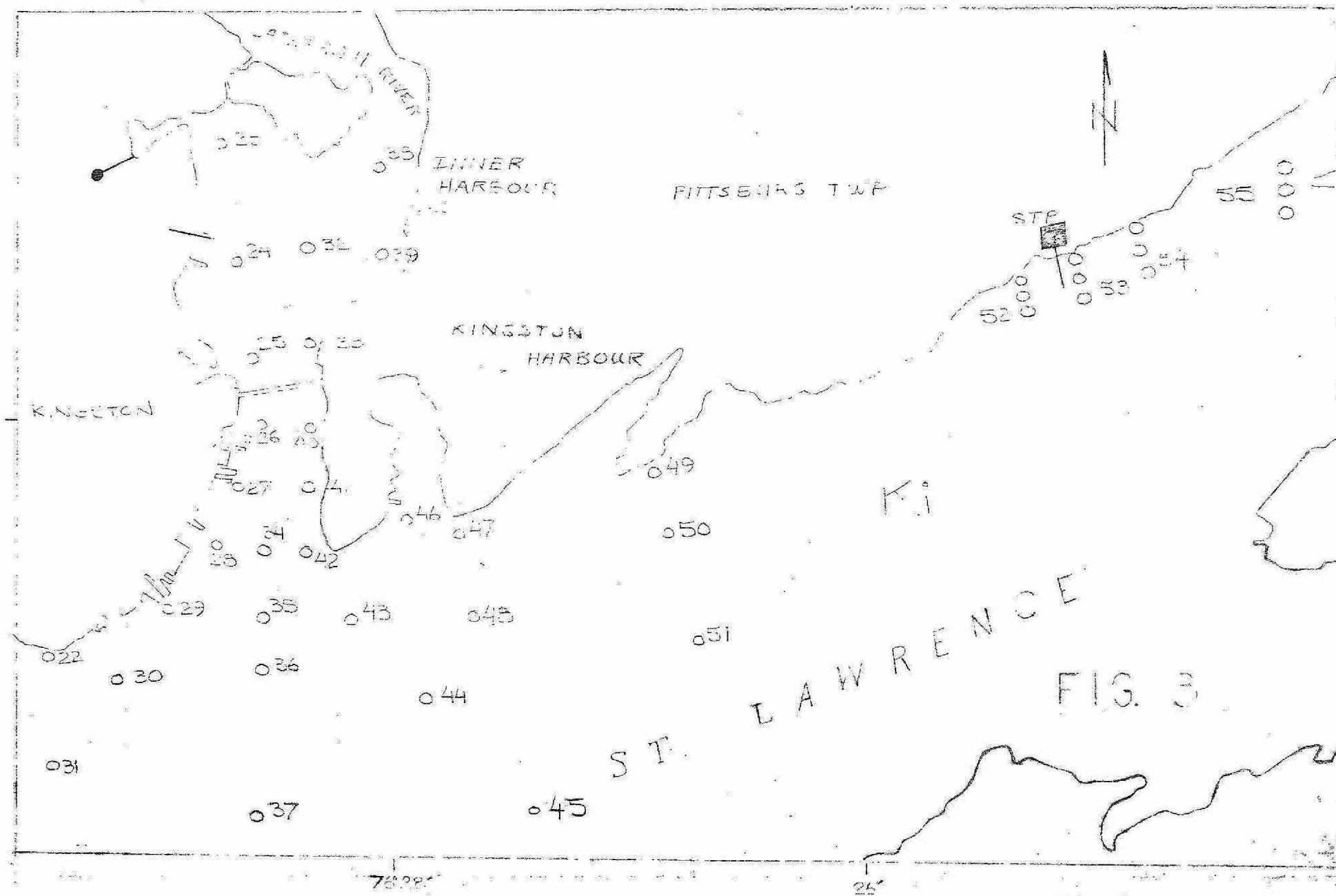


FIG. 2



The distribution of bottom fauna within and at the mouth of the Cataraqui River clearly indicated moderate to gross impairment of water quality adjacent to the Kingston shoreline. At stations 23, 24 and 25, the mean number of taxa per station was 3.7, representing only midge larvae and tubificid worms. In comparison, 11 and 12 taxa were taken at stations 38 and 39 respectively, located upstream of Kingston, including a variety of forms intolerant of organic pollution (caddisflies, mayflies, clams, snails and amphipods). Diversity of fauna at stations 32 and 33 was intermediate between that observed adjacent to and upstream of Kingston. Within the outer harbour, stations 26 to 29 (exclusive of 28 where a hard bottom prevented dredging) and station 40 yielded a mean of 1.7 taxa per station. No macroinvertebrates were obtained from samples at stations 27 and 40.

Further offshore at stations 34 and 35, communities consisted of 9 and 10 taxa respectively and were similar to those at offshore stations west of the Cataraqui River. This was also the case at stations 46 to 50 off Pittsburg Township. In greater depths east of Kingston, communities were comprised in most cases of only midge larvae occurring in high numbers. These conditions undoubtedly reflected the greater fertility of Cataraqui River water and nutrient content of municipal wastes from Kingston, rather than any direct effect of organic pollution from Kingston. (Summer stratification of these waters is most likely but was not examined in this survey.) Mean numbers of taxa collected at stations 52, 53, 54 and 55

were 6, 7, 4 and 6 respectively. Composition and variety of taxa within communities at these stations were influenced to a large extent by variability of substrate. While polluttional effects could not be clearly defined, the reduced number of taxa and greater abundance of pollution-tolerant forms at station 54 suggested minor and local impairment of water quality downstream of the sewage treatment plant outfall.

Brockville

The Brockville waste treatment system is comprised of a primary treatment plant, four sewage pumping stations, and sanitary and storm sewers which are to a large extent combined. These facilities service a population of approximately 17,000 and a variety of manufacturing industries. The sewage treatment plant was designed for an average flow of 3.75 mgd; the final effluent is chlorinated before being discharged to the St. Lawrence River near the eastern boundary of the city. Periodic hydraulic overloading of the system results in discharges of untreated domestic and industrial wastes to the river and to Butler Creek through numerous storm sewer outfalls and by-pass facilities at the sewage pumping stations. In areas of the city not serviced by the municipal system, septic tanks are employed for sewage disposal. Several of these which discharge directly to the river provide inadequate treatment. At the time of this survey, industrial wastes were being discharged to surface waters from two sources. Process wastes from Phillips Cables Limited, containing high levels of BOD, solids, phenols and copper, are discharged to

Butler Creek in the vicinity of Church and Beecher Streets. Periodic discharges of contaminated cooling water from this plant to the St. Lawrence River at Bayview Street have been noted. The Wrightway Laundry and Cleaners discharge wastes from three commercial washers and from a 14-unit laundromat to the river immediately west of the mouth of Butler Creek.

Bottom fauna populations were examined at eight stations along the Brockville shoreline. The location of these relative to waste outfalls is illustrated in Figure 4.

A comparison of bottom fauna populations at stations 1A, 1 and 2 revealed no apparent effect of industrial waste discharges at Bayview Street. Balanced and diverse communities occurred at each station. The notably greater variety of taxa at station 1A (32), as compared to that at stations 1 and 2 (12 and 11), was most likely attributable to the abundance of macrophytes and diversity of physical habitats at station 1A rather than to any appreciable differences in water quality between these stations. At station 3, situated at the mouth of Butler Creek and within the breakwall fronting on Hardy Park, only three taxa were collected consisting of two genera of midge larvae (Pentaneura and Procladius) and one genera of Tubificidae (Limnodrilus). Low densities of organisms and greatly reduced diversity indicated moderate to gross toxic pollution at this site. A similar community consisting of a few specimens each of Procladius spp. and Limnodrilus hoffmeisteri at station 4a (within 30 feet of shore) as

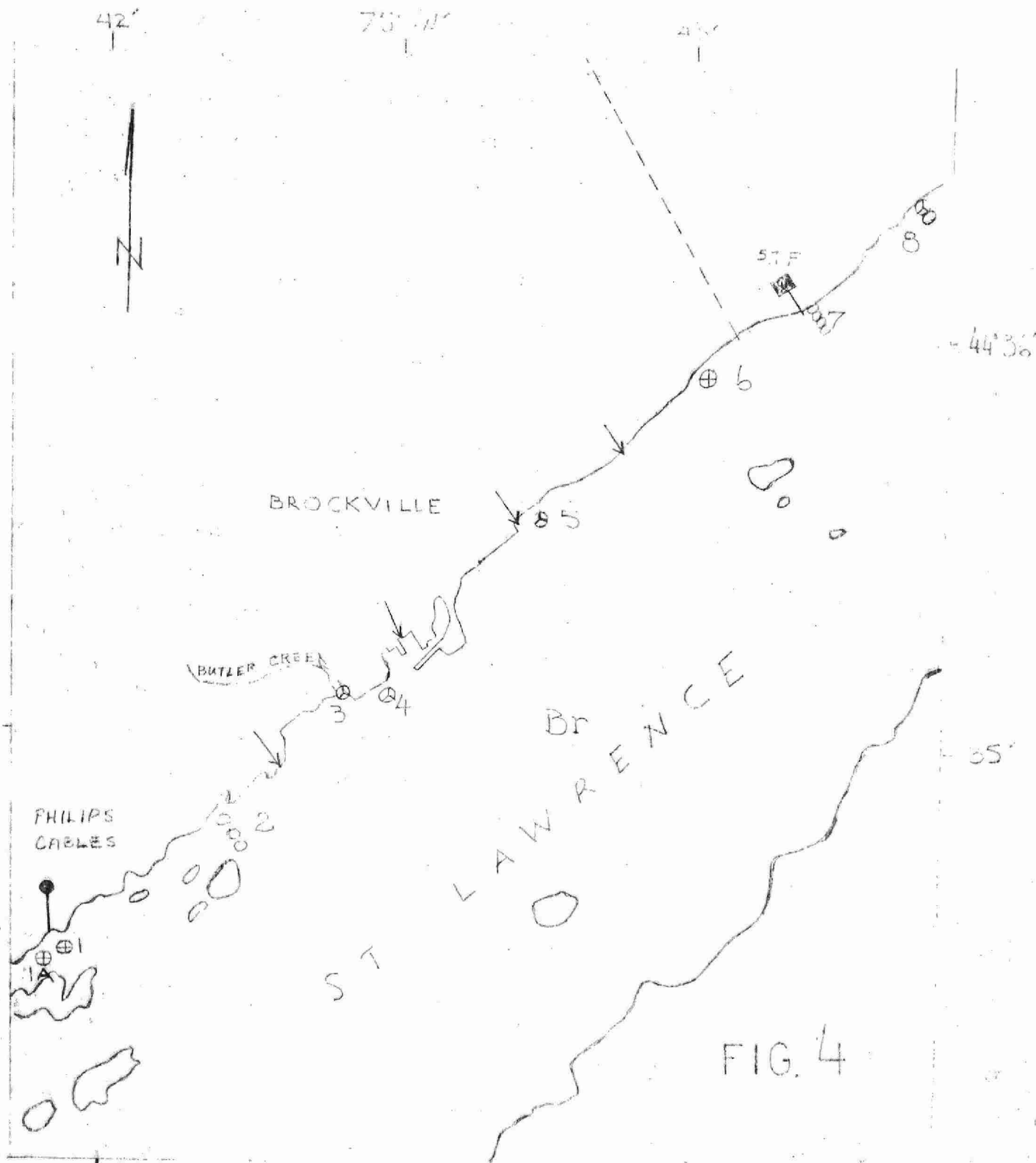


FIG. 4

compared to 12 taxa and balanced species composition at sites 100 feet and further offshore at this point indicated the adverse effect of Butler Creek on near-shore waters of the river for a distance of at least 500 feet downstream. At station 5, 75 feet and 100 feet offshore, only 8 taxa were sampled and no organisms were obtained in one sample taken approximately 50 feet from shore. On the basis of these results, it would appear that periodic discharges of untreated municipal wastes at the Water Street pumping station and possibly from the Ford Street storm sewer have had a detrimental effect on water quality in the vicinity of these outfalls. Because of the variability in substrate at stations 6, 7 and 8, no conclusions could be made with respect to water quality from a comparison of communities at each. However, the presence of 17 taxa, including pollution-intolerant forms at station 8, indicated that no significant adverse effect on water quality could be attributed to the sewage treatment plant effluent.

Maitland

Bottom fauna was examined in the vicinities of waste discharges from Brockville Chemicals Limited and Du Pont of Canada, Limited (Maitland Works) which are located on the St. Lawrence River approximately two miles east of the Village of Maitland. Brockville Chemicals is engaged in the manufacture of chemicals and fertilizers. A waste volume of 400,000 gpd. containing high levels of BOD (32 ppm), nitrates (150 ppm) and ammonia (300 ppm) is discharged to the river at the bay immediately west of the plant. Sanitary wastes from the plant receive adequate secondary

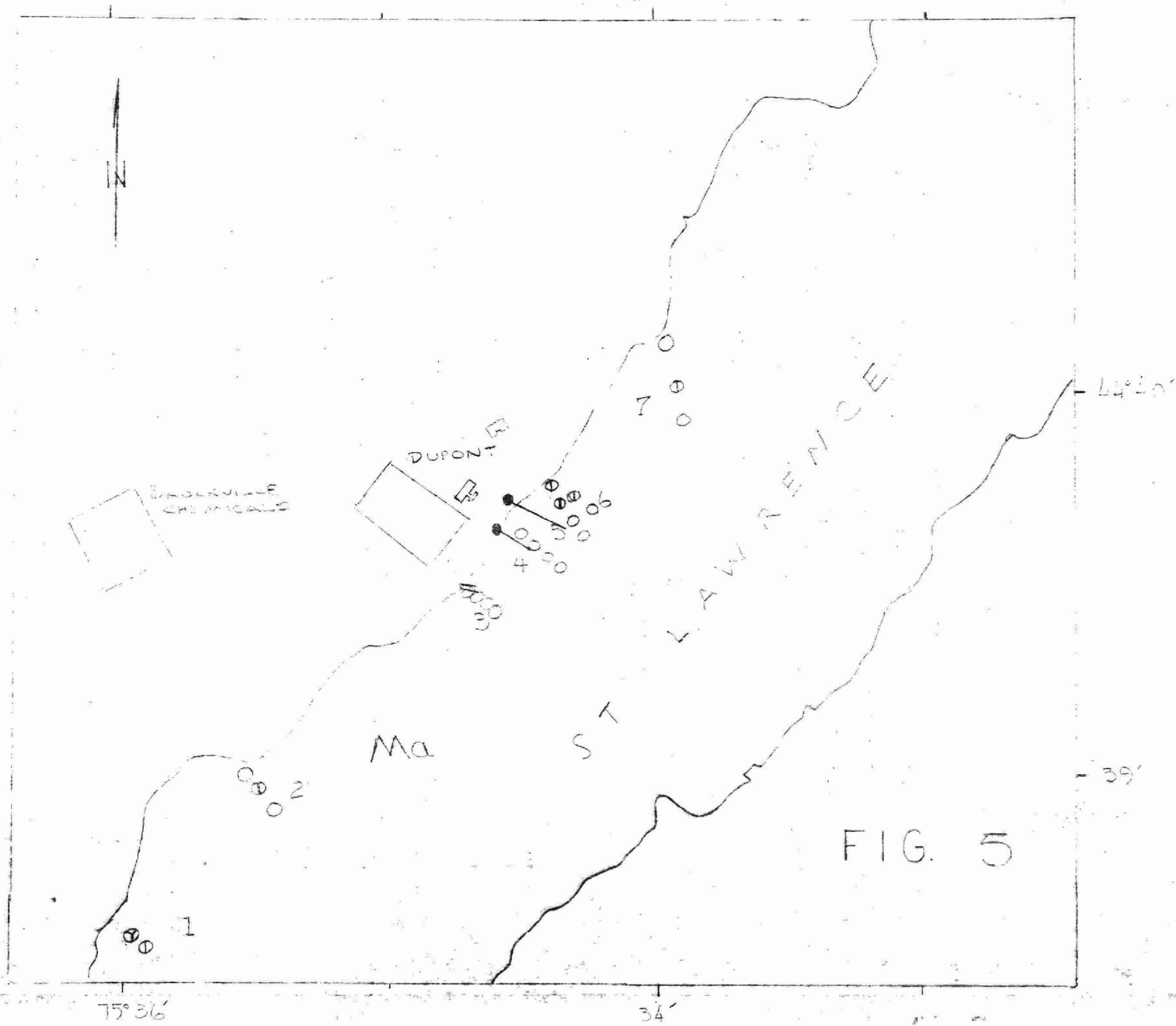
treatment. Du Pont produces nylon intermediates, acrylic fiber, spandex fibre, freon, hydrogen peroxide and more recently tetraethyl lead. Process waste-water which includes a multiplicity of complex organic compounds are discharged through a submerged outfall extending approximately 900 feet into the river. A volume of 34 mgd of contaminated cooling water is passed through three detention ponds before being discharged to the river through a 450-foot submerged outfall. The latest industrial waste survey reported a total waste volume of 35 mgd containing the following waste loadings:

	lbs/day
5-day BOD	35, 400
COD	54,000
ammonia nitrogen	9,000
Kjeldahl nitrogen	10,400
lead	92
copper	188

A septic tank is employed to treat sanitary wastes from the Du Pont plant. This facility was reportedly overloaded at the time of the survey; extensions and modifications have been planned.

The location of survey stations and position of waste outfalls are shown in Figure 5.

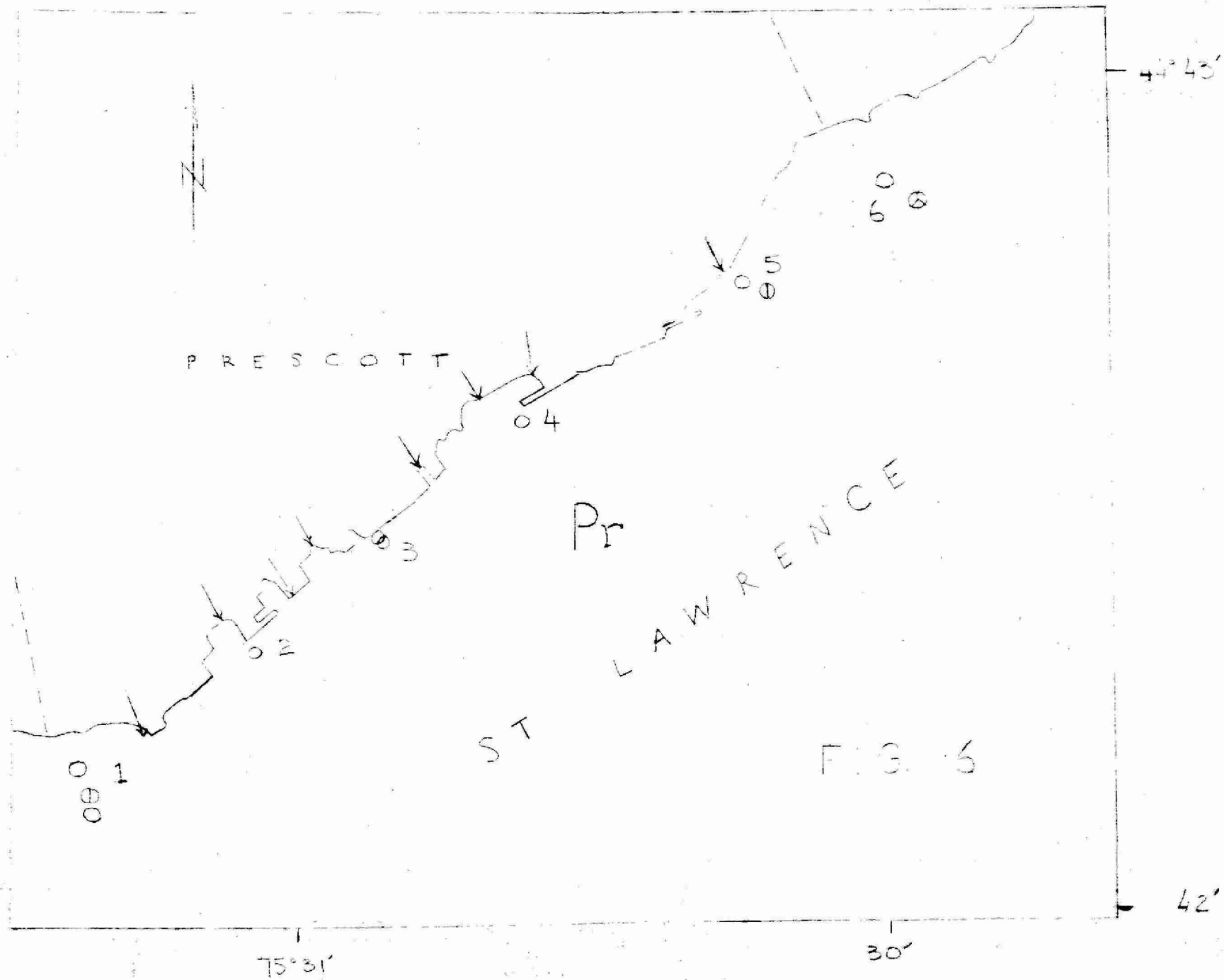
A significant reduction in diversity of fauna was noted at station 2. A total of only four taxa from the three sampling sites, consisting of midge larvae and tubificid worms, was collected as compared to a total of 20 taxa found upstream at station 1. The location of the waste outfall from Brockville Chemicals located within the



bay between these stations was not precisely determined relative to the location of station 2. Turbid waters arising within the bay from wave action on the clay bluffs forms a noticeable plume passing over station 2. This was observed commonly in the course of field work and might account, to a large degree, for the results obtained. Thirteen taxa were collected at station 3 representing most of the groups sampled at station 1. The results obtained at this station may be used only in a general way for comparisons with those obtained at station 4, 5, 6 and 7 below waste outfalls from the Du Pont plant because of variations in substrate and to some extent depths between stations. For these reasons and because of the extremely limited amount of sampling accomplished to date, no conclusions could be drawn with respect to the degree and extent of pollutional effects from Du Pont waste discharges. However, a noticeable reduction in diversity of communities below these discharges was observed which, it is felt, could not be entirely related to less favourable substrate or to sampling error. Further biological survey work of a more intensive nature should be undertaken in which variability due to physical factors and sampling error may be accounted for. Fish bioassays should be continued by personnel of the Du Pont plant with particular attention to waste streams from the tetraethyl lead plant. The biological assessment of pollution is particularly useful in this situation because of the complex nature of these wastes.

Prescott

Prescott, with a population of about 5,200, is situated on the St. Lawrence River in the Township of



Augusta approximately seven miles east of Maitland and opposite Ogdensburg, New York. To date, sewage treatment facilities have not been provided by the municipality. The existing sewage system consists of three storm sewers and five sanitary sewers which discharge directly to the river. Sewers are combined to an undetermined extent. Industrial waste contaminants discharged to the system include zinc, nickel and cyanide from plating and dyeing processes.

Figure 6 shows the distribution of sampling sites relative to municipal waste outfalls at Prescott.

Bottom faunal communities were notably restricted at all stations relative to those observed throughout other river reaches having comparable physical habitats. The number of taxa per sample varied between one and five; midge larvae, tubificid worms, snails and clams were predominant groups at most stations. No marked differences were apparent between stations with respect to composition of communities, diversity of forms or abundance of organisms. Consequently, no conclusions could be drawn concerning water quality conditions on the basis of these data. More intensive sampling at these and additional stations will be required to adequately define water quality.

Chemical analysis of river water during this survey and in the course of previous surveys has revealed no significant contamination. However, high coliform counts have been noted in Kelly's Bay which has periodically curtailed the use of the public beach. In this survey, excessive coliform levels (9,000/100 ml.) were determined only at station 4.

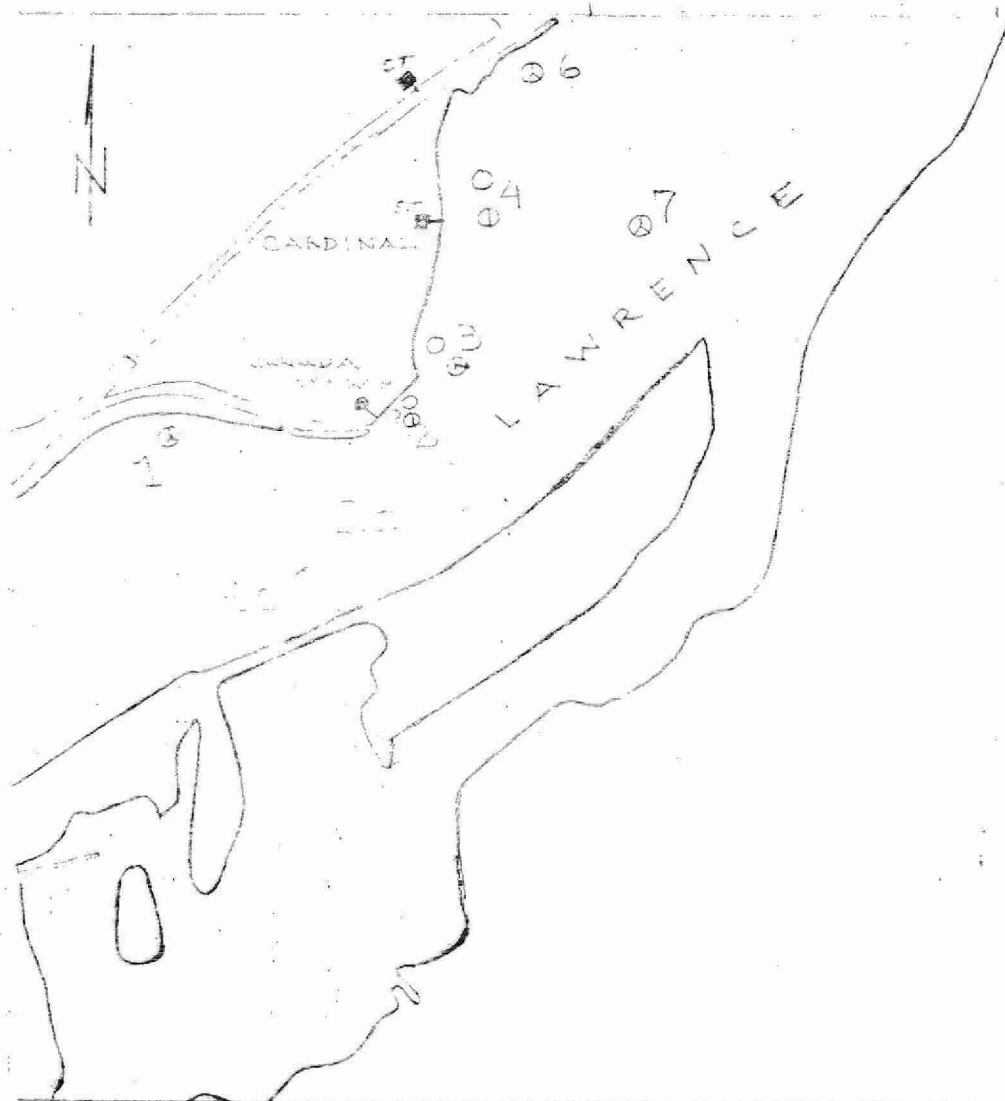
Cardinal

The village of Cardinal, population approximately 2000, is located on the St. Lawrence River near the eastern boundary of the County of Grenville. Domestic wastes from the northern section are directed to a septic tank which discharges to the Gallop Canal, on the east side of the village. Sanitary wastes from the south section are directed to a second septic tank located on the river at the east end of the village. Excessive hydraulic overloading occurs in both cases resulting in less than 40 per cent reduction in 5-day BOD at the north septic tank and negligible treatment at the south tank. In both cases, effluents are discharged without the benefit of chlorination.

The only industry in Cardinal is the Canada Starch Company, Limited. Corn starch and related by-products are produced by the wet-milling process. According to the latest report of waste loadings, a total volume of 5.5 mgd containing 13,500 pounds of 5-day BOD and 6,800 pounds of suspended solids is discharged to the St. Lawrence River. Of this total, 435,000 gpd are directed to the south septic tank along with sanitary wastes from the industry. In 1965, and more recently, changes in plant operation have been effected which should reduce quantities of wastes. Consequently, waste loadings, mentioned above, may have been somewhat reduced at the time of the survey.

Bottom fauna was examined at six locations in the river above and below waste outfalls (Figure 7).

At station 1 (control) a total of 12 taxa were collected including genera of midge larvae, tubificid worms, snails and clams. While caddisflies and amphipods were not taken at this station, the community was balanced and probably typical of unaltered water quality. A comparison of fauna at this station with that at stations 2 and 3 below the Canada Starch outfalls, indicated moderate to gross impairment of near-shore waters for a distance of at least 1000 feet downstream. At a sampling site 100 feet from shore and 25 feet below the discharge (station 2) no benthic organisms were obtained. At a point 200 feet downstream and 100 feet offshore, the fauna consisted only of the pollution-tolerant worm, Limnodrilus, in low numbers. Between these two sites but further offshore (250 feet) more intolerant forms (Cheumatopsyche, lumbriculid worms, and fingernail clams) were predominant. A greater diversity at this site was probably prevented by coarser sediments rather than any appreciable degradation of water quality. At station 3, approximately 1000 feet below the Canada Starch outfall, bottom fauna within 200 feet of shore consisted of an abundance of midge larvae (Tendipes). The mixed community of midge larvae and low numbers of tubificid worms indicated little improvement over conditions noted 200 feet below the outfall. At station 3, approximately 500 feet offshore, communities were dominated by worms and midge larvae but a greater variety of taxa within these two groups indicated some improvement over conditions closer to shore at this station. The upstream sampling site at station 4, located approximately one-half mile below the Canada Starch outfall, yielded a total of



44° 46'

FIG. 7

45'

75° 22'

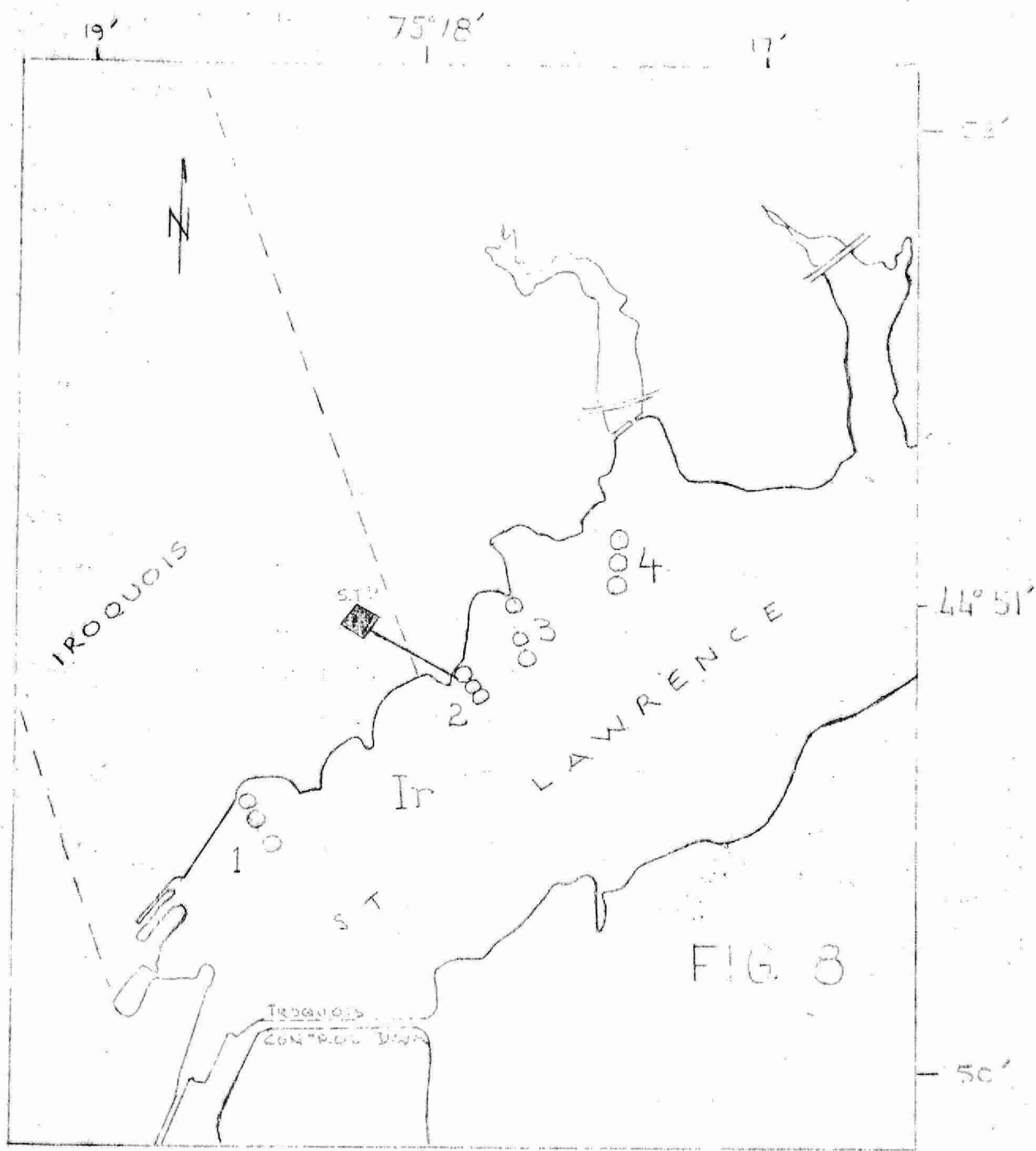
10 taxa; while midge larvae and worms were predominant, a variety of genera within these groups were taken, along with a few representatives of snails and clams. Except for the greater abundance of worms and midges, indicative of organic enrichment, the community was similar to that at station 1. The downstream sampling site at station 4 and sites at station 6 yielded an average of only three taxa per sample, as compared with 10 taxa upstream at station 4, and 12 and 11 taxa respectively at control stations 1 and 7. Undoubtedly, bottom fauna was restricted to a large part by coarser sediments (gravel) at these sites. Consequently, it was difficult to interpret pollutional effects on the basis of these data.

Chemical analysis of water samples taken at the time of the biological survey yielded values within Commission objectives. A value of 3,700 coliforms per 100 ml at station 6 revealed moderate bacterial contamination.

In summary, adverse effects on bottom fauna of the river from waste discharges from Canada Starch Company Limited were evident in near-shore waters for a distance of up to one-half mile downstream. Survey results were generally inconclusive with respect to effects of discharges from the south septic tank although related bacterial contamination was noted.

Iroquois

Sanitary wastes from a population of approximately 1,100 and industrial wastes from Caldwell Linen Mills Limited at Iroquois receive primary treatment. The plant, with a design capacity of 450,000 gpd, is



situated near the eastern boundary of the village. The primary effluent is chlorinated and discharged to the St. Lawrence River at the shoreline. Flows in excess of design capacity are by-passed to the river in the vicinity of the primary effluent outfall.

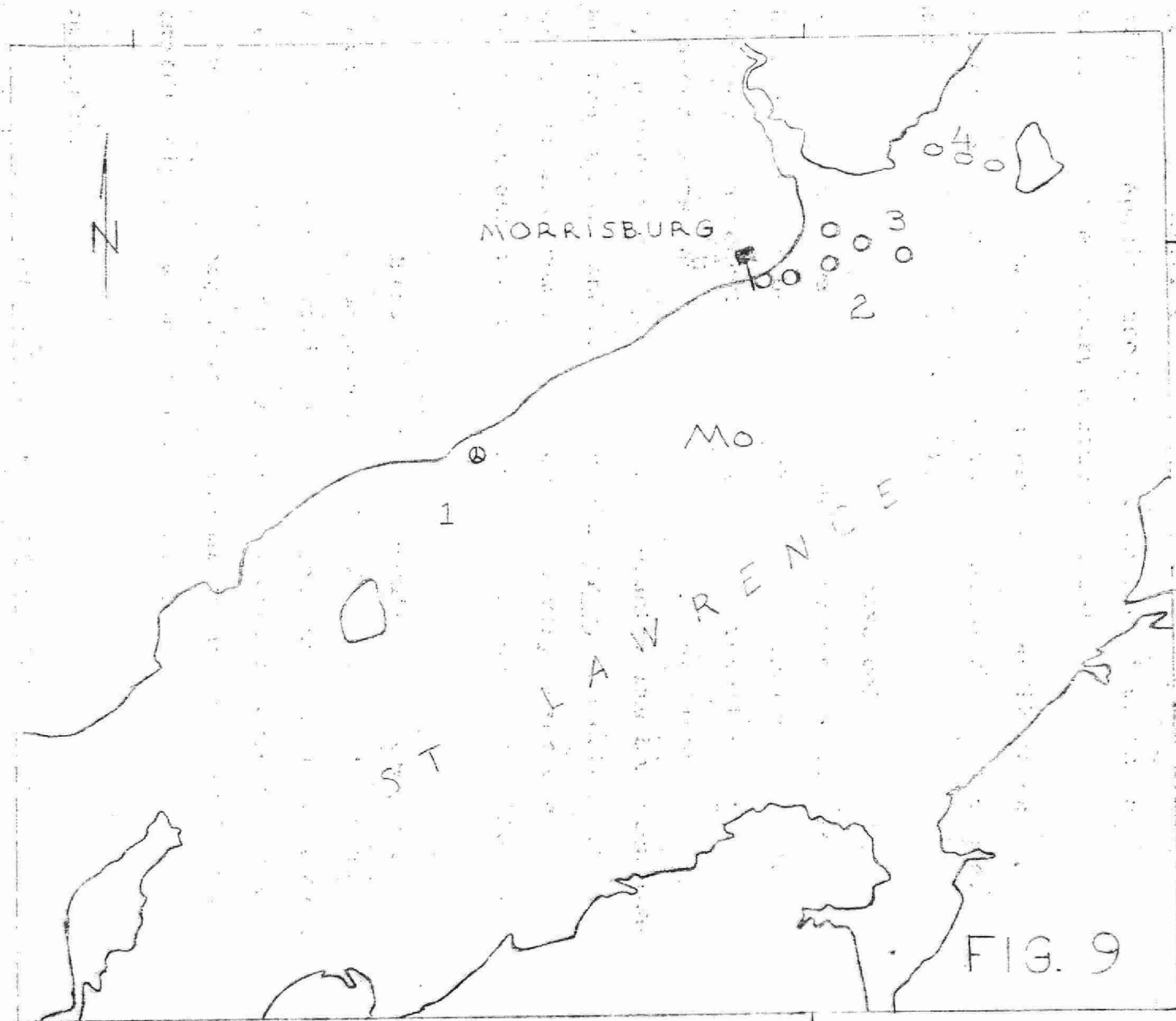
Bottom fauna was sampled at 12 sites located at four stations above and below the sewage treatment plant outfall (Figure 8).

The total numbers of taxa collected at stations 1 to 4 were 10, 4, 6 and 6 respectively. Fewer taxa at stations below the outfall as compared to station 1 was due to a reduction in midge larvae resulting from coarser, less favourable substrate. At stations 2 and 3, the presence of pollution-intolerant worms Lumbriculidae and Manayunkia, and amphipods, Gammarus, indicated little effect if any from this source. The very restricted fauna at station 2 may have been due in part to pollutional effects.

Chemical results revealed no values for parameters tested in excess of Commission objectives and no major dissimilarities between stations. Coliform counts were generally within Commission objectives except for a value of 7,300 organisms per 100 ml obtained at station 2 immediately below the municipal outfall.

Morrisburg

Sanitary wastes from a population of approximately 1,800 at Morrisburg are directed to a primary treatment plant having a capacity of 500,000 gpd.



75°12'

10'

FIG. 9

The primary effluent is discharged to an oxidation lagoon which in turn discharges to the St. Lawrence River.

Collections of bottom fauna at stations above and below the outfall (Figure 9) yielded little information concerning the effects of this waste source. The number of taxa at several sites (stations 2 and 3) below the outfall exceeded that obtained at station 1, and included a number of taxa generally considered to be intolerant of organic pollution. The number and composition of taxa, which was quite variable within and between stations, was undoubtedly related more to substrate types than to chemical quality of the river.

Cornwall

Cornwall, with a population of approximately 44,400 is situated on the St. Lawrence River immediately downstream of the Moses-Saunders power dam. No sewage treatment facilities have been provided by the municipality to date. Domestic and industrial wastes from numerous industries are carried by combined storm and sanitary sewers to the St. Lawrence River and to several tributary streams. Major quantities of industrial wastes originate from operations of the Domtar Pulp and Paper Limited and Courtaulds (Canada) limited and related firms (Courtaulds group). The former produces fine paper from the Kraft milling process. According to the latest industrial waste survey (1964), 42.9 mgd of wastes are discharged to the St. Lawrence River through the Fly Creek sewer containing 206,000 pounds of 5-day BOD and 219,000 pounds of suspended solids. The

Courtaulds group is engaged in the production of viscose, rayon, tufted carpet and cellulose film. A waste volume of 12.8 mgd from these processes are discharged to the river containing 4,300 pounds of 5-day BOD, 4,100 pounds of suspended solids and 120,000 pounds of sulphate as SO_4 .

The municipality has embarked on a program of storm drainage and sewage works scheduled for completion by 1970. Waste treatment facilities will include primary settling, effluent chlorination and an outfall sewer extending into the main stream of the St. Lawrence River west of Pilon Island. On completion, these facilities are expected to handle all municipal wastes with the exception of sanitary and industrial wastes from the Domtar mill and industrial wastes from the Courtaulds group.

The river at Cornwall is divided by Cornwall Island into a north channel (Cornwall Channel) and a south channel. The Cornwall Channel carries approximately one-third of the river flow discharged through the Moses-Saunders power dam with the remaining two-thirds passing through the Polly Gut to the south channel. Additional flows from Lake St. Lawrence through the seaway locks and the Massena diversion enter the south channel. Most of the flow from the south channel passes between Cornwall Island and St. Regis Island to join the flow from the Cornwall Channel. Flow characteristics of the Cornwall Narrows and upper Lake St. Francis have reportedly been unaltered by the recent Seaway development.

Bottom fauna collections were made at a total of 54 stations in the Cornwall Narrows and in Lake

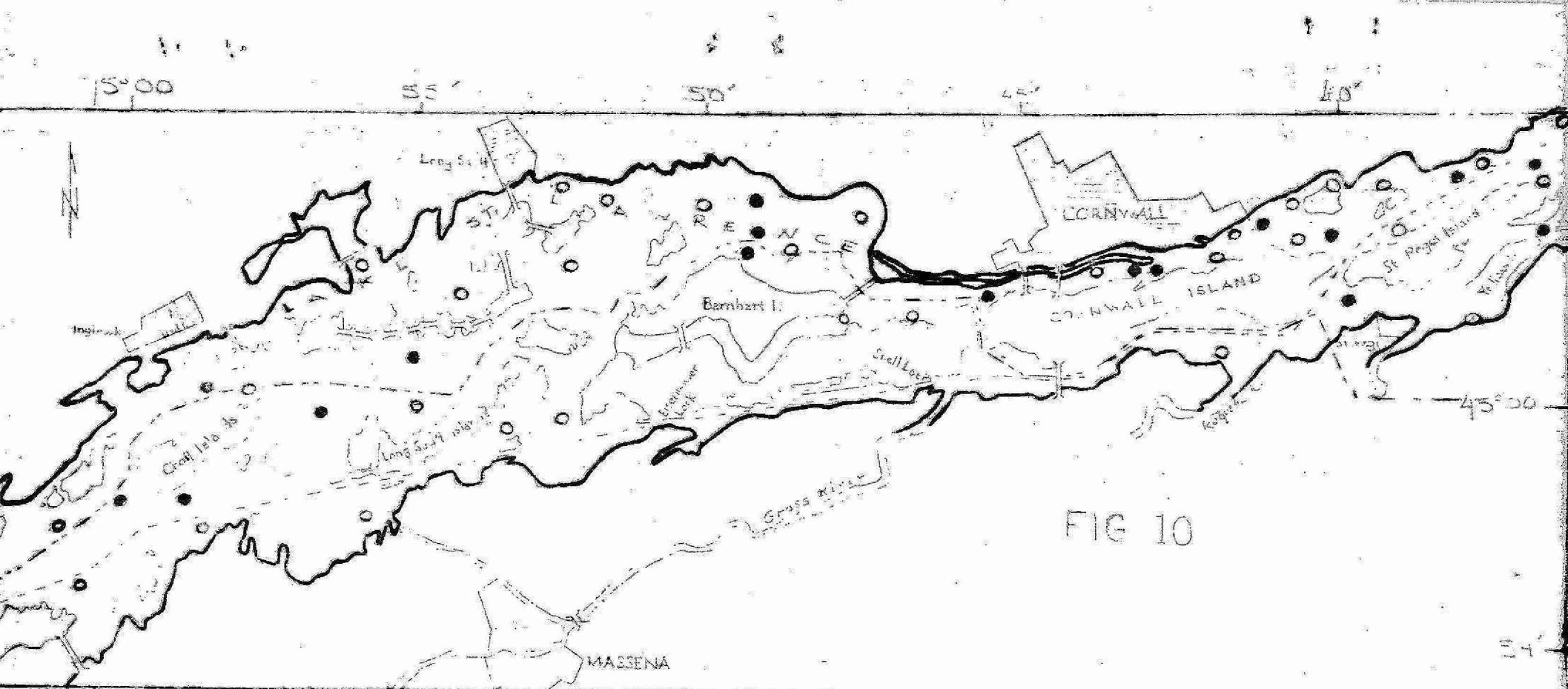
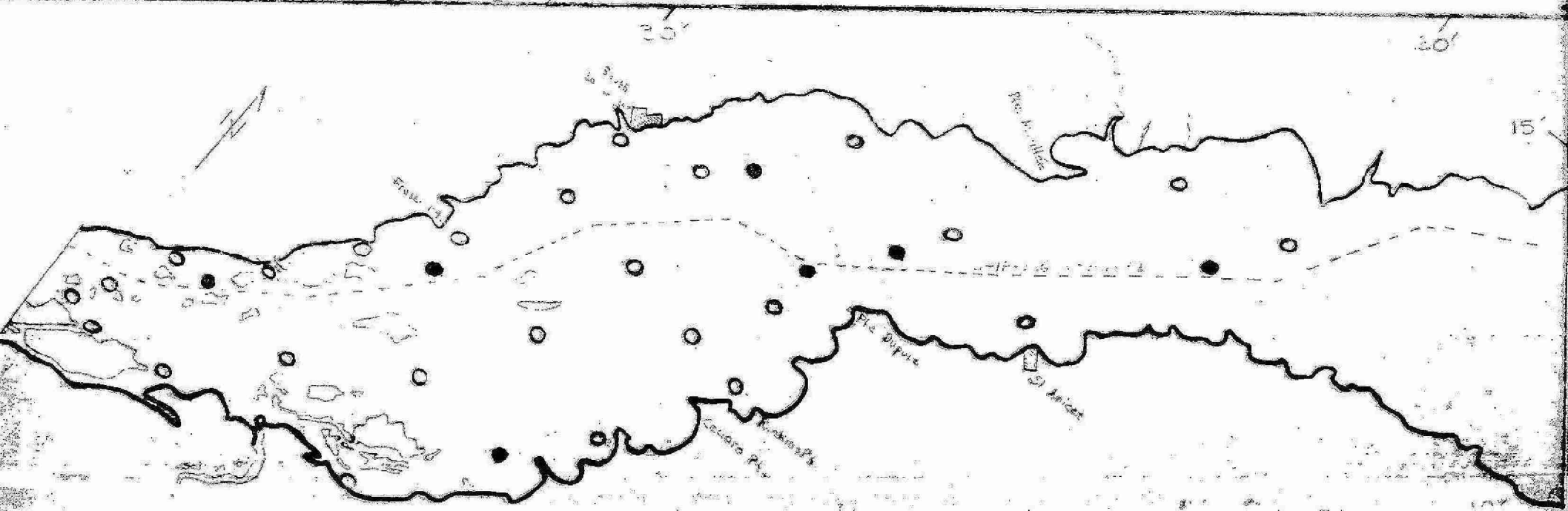
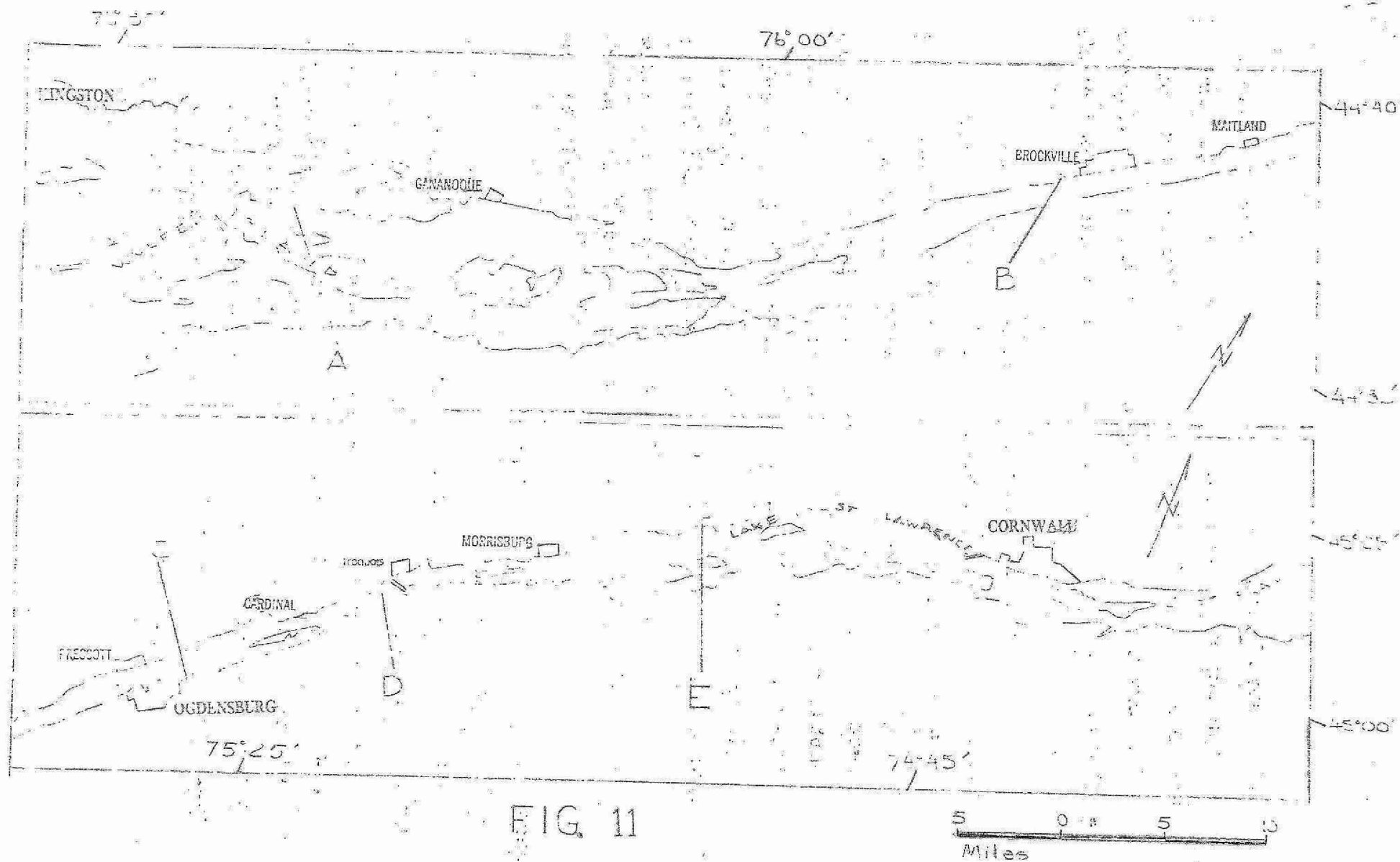


FIG 10



St. Francis downstream to the Quebec-Ontario border (Figure 10). Of these, 11 were located along the north shore (Cornwall waterfront) and south shore of the Cornwall channel. At stations within 500 feet of the Cornwall shoreline at distances of 0.6, 2.2 and 3.1 miles downstream of the Domtar mill outfall, no organisms were found in dredge samples. At these sites the bottom was blanketed with bark and woodchips. A community dominated by midge larvae and tubificid worms occurred approximately one mile below the mill where a greater current velocity precluded the deposition of these solids. In comparison, stations along the south shore of the channel yielded an average of 13 taxa consisting predominantly of pollution-intolerant forms. From these results, it was clearly evident that near-shore waters along most of the Cornwall waterfront were grossly impaired. However, on the basis of the few stations sampled, it was not possible to fully assess the effects of specific waste outfalls.

At stations downstream of the Cornwall Channel where flows are combined with those from the south channel and throughout Lake St. Francis, an average of 8.7 taxa per sample for all stations was obtained. Diversity varying from three taxa to 17 taxa per sample coincided with availability of suitable substrate. Clean-water forms, notably caddisflies, mayflies, amphipods and a variety of molluscs were common to the majority of stations. These results, therefore, yielded no evidence of impaired water quality downstream of the Cornwall Channel.



Transects

The position of transects downstream to Lake St. Lawrence and stations in Lake St. Lawrence are shown in Figures 11 and 10 respectively.

From an examination of bottom fauna communities at the 24 stations located throughout the study area, no adverse changes in water quality or downstream variations could be detected. Generally, these stations exhibited balanced, diversified fauna with low to moderate densities. Pollution-intolerant caddisflies, mayflies, amphipods, clams and snails were common to most reaches of the river. The average number of taxa at all stations was 9.8, ranging from a high of 13.2 in areas of appreciable flow to a low of 4.4 in Lake St. Lawrence, where substrate types were relatively homogeneous and where populations were not yet stabilized in areas of recent flooding. Differences in diversity of fauna in different reaches of the river and between stations at each transect were attributed in all cases to natural variations in the physical environment.

Aquatic Vegetation

Since 1962, public reports have been received of nuisance conditions in the St. Lawrence River, resulting from excessive growths of aquatic vegetation. Such reports have clearly indicated excessive production of aquatic macrophytes and filamentous algae in certain sections of the river. Field work in 1966 and 1967 provided an opportunity of making preliminary observations on species composition, distribution and relative abundance of vegetation and a general assessment of related problems.

Specific vegetation surveys in June of 1967 covered the shoreline from Bath to Kingston, Gananoque to Ivy Lea in the Thousand Island region and from Grenadier Island downstream to upper Lake St. Lawrence. Observations of a more general nature were made in Lake St. Francis in the course of field work during August and September of 1966.

Bath to Kingston

Because of the exposed nature of this shoreline, bedrock and cobblestone substrate occur extensively in the littoral regions and provide large areas suitable for the growth of filamentous algae, Cladophora. The extent of areas of finer sediments, within depths suitable for growth of rooted aquatic plants, is limited. Observations made in 1963 revealed that Cladophora growths along most of this shoreline occurred only as a fringe at the waterline and did not extend over suitable rock substrate at depths in excess of one or two feet. By comparison, in 1967, Cladophora growths were significantly more abundant and extensive along this shoreline with dense growth beds occurring to depths of at least 10 feet. Within this area, production was noticeably greatest along the Kingston waterfront as a result of enrichment from a number of municipal waste outfalls. West of Kingston, production was sufficient to cause nuisance accumulations within shallow bays which, at the time of these observations, were decomposing and highly malodorous. Adverse effects of these accumulations on the use of beaches for swimming and other recreational activities was evident from reports given by personnel at Fairfield Park near Collins Bay.

Gananoque to Ivy Lea

Within this region of the Thousand Islands, depths, shore profiles and bottom types are quite variable. The confined nature of these waters has permitted deposits of silt and fine organic matter over extensive areas within depths suitable for growth of rooted aquatic plants. On the other hand, bedrock and boulder substrate was, in most cases, limited to areas in the immediate vicinity of shorelines. While Cladophora occurred generally throughout the area, the extent of growth beds was limited by physical features. Along the mainland shoreline production was greatest, particularly near Gananoque, where growths ranging in length from six inches to one foot covered between 75 and 100 per cent of suitable substrate. Around islands and rocky shoals from one to two miles offshore, growths were comparatively sparse with filaments up to six inches long covering less than 50 per cent of growth areas. Because of limitations by physical factors, it is doubtful that Cladophora production in these waters will ever reach nuisance proportions over large areas. However, depending on physical features of shorelines, problems might occur in localized situations.

In these waters, abundance of emergent and submergent macrophytes is probably of greater significance with respect to recreational uses. Emergent vegetation in bays and at river mouths consisted commonly of dense, uniform stands of cattail, Typha latifolia, bordered by bulrush, Scirpus spp. which obviously affect the

usefulness and perhaps aesthetic qualities of the shoreline. Submergent vegetation, while common throughout most of this area had not reached maximum growth at the time observations were made. The common species in order of frequency of occurrence and general abundance were pondweeds, Potamogeton crispus, P. Richardsonii, Potamogeton spp. (narrow-leaf), eel grass Vallisneria americana, and water milfoil Myriophyllum spp.

Grenadier Island to Jones Creek

In this portion of the river there are extensive areas along the north shore where depths are less than 12 feet and which are removed from the main flow of the river. Sediments consist largely of a mixture of sand, silt and organic matter. Only limited areas of rock substrate occur off points of land, islands and scattered offshore shoals.

Cladophora was distributed commonly throughout the area and dense, abundant growths covering 100 per cent of suitable substrate was noted in most cases. No accumulations or other problems associated with these growths were observed.

In the area between Grenadier Island and the mainland, submergent vegetation was particularly abundant over large areas having depths of less than five feet. While composition of associations was variable, the order of frequency of occurrence and general abundance was pondweeds P. crispus, P. zosteriformis, and P. Richardsonii; Canada water weed, Anacharis canadensis; water milfoil;

narrow-leaf pondweed; eel grass and musk grass, Chara spp. Growths of filamentous algae, Spirogyra, were common on submergent vegetation.

Along much of the mainland shoreline extending downstream of Jones Creek, there were dense stands of cattail and bulrush. Only short, scattered growths of submergents, predominantly P. crispus and P. Richardsonii, were noted in depths up to 12 feet.

Jones Creek to Prescott

Limestone cliffs and boulder beach forms much of the shoreline between Jones Creek and Maitland. Shore profiles are steep and substrate consists usually of bedrock or cobblestone giving way to sand at depths of 12 to 15 feet. Gravel and rock bottom are common at depths greater than 35 feet under the influence of stronger currents. Exceptions to this general pattern were bays and the region of the Brockville Islands where shallow water areas and silt and organic sediments were more extensive. In these areas, the abundance and composition of submergent vegetation was similar to that noted previously. Cladophora was commonly distributed throughout this area. While growth beds were not extensive, algae was abundant on all rock substrate to depths of 15 feet and production was noticeably greatest below sources of added enrichment. This was the case for a distance of approximately two miles below the Brockville sewage treatment plant outfall, below Brockville Chemicals Limited near Maitland and for a distance of from one to two miles below Prescott.

Prescott to Upper Lake St. Lawrence

Downstream of Prescott, rock substrate within the littoral zone was less prevalent than in upstream reaches and was confined chiefly to immediate shoreline areas between Iroquois and Morrisburg. Cladophora growths were generally sparse, covering less than 30 per cent of available substrate and in some cases occurred only as a fringe at the waterline. However, growths were more extensive and production noticeably greater below sewage treatment plant discharges at Iroquois and Morrisburg.

Significant growths of submergent vegetation were noted only upstream of Iroquois throughout extensive areas providing suitable conditions of shallow water and fine sediments between the shipping channel and the north shore of the river. Most common species were P. crispus, narrow-leaf pondweed, eel grass, and Canada water weed. Below Morrisburg, recently flooded land forms much of the littoral zone and appreciable growths of submergent vegetation have not become established.

Lake St. Francis

Upper Lake St. Francis is typical of a delta region where river flow from the Cornwall Narrows divides into a number of channels and rate of flow diminishes as the river widens. Between these channels and along the north and south shore of the lake there are extensive areas with depths of less than 30 feet and often less than 15 feet. Decreased current velocity has permitted

deposition of finer, organic sediments over the years and physical features are favourable for the accumulation of nutrients from upstream sources.

General observations made during late July and August of 1966, revealed excessive production of aquatic macrophytes throughout the entire upper portion of the lake with the exception of channels deeper than 20 feet where current velocities were appreciable. Depths of less than five feet occurred over extensive areas along the south shore and between Summerstown and South Lancaster on the north shore. Dense stands of cattails, T. latifolia and T. angustifolia, and bulrush, Scirpus spp., exhibited advanced stages of plant succession. Submergent vegetation in association with bulrush was common. Submergent vegetation was also abundant throughout most of the deeper, open-water areas where pondweeds often attained lengths of 15 feet. While these observations did not permit detailed descriptions of composition and relative abundance of growths, most common and generally abundant species were P. crispus, P. Richardsonii, narrow-leaf pondweed, Canada water weed, eel grass, water milfoil and bladderwort, Utricularia spp. In August, filamentous algae, Spirogyra, was extremely abundant both free-floating and attached to submergent vegetation throughout most of the lake. No apparent differences were observed between north and south shore areas of the lake.

A comparison of phytoplankton populations in samples collected from Lake St. Francis, September 8, 1968, and from Lake St. Lawrence, September 23, 1968, showed no meaningful quantitative or qualitative differences.

A low mean standing crop of 86 a.s.u. per ml. and a mean of 13 taxa were obtained from surface water samples at three stations in Lake St. Lawrence, as compared with means of 66 a.s.u. per ml. and 13 taxa from a total of 13 stations in Lake St. Francis. Green algae were predominant in samples from both lakes and the percentage composition of blue-greens, flagellates, greens and diatoms were essentially similar in all samples.

Complaints received from the public and interviews held with commercial fishermen, anglers, marina operators and parks personnel, emphasized the following problems related to adverse effects of vegetation on recreational and other uses of these waters.

1. Commercial fishing operations are severely restricted owing to the fouling of gill nets by drifting filamentous algae (probably Spirogyra) and difficulties with setting, fishing and general efficiency of trap nets where submergent vegetation is abundant.
2. reduction of open water areas desirable for sport fishing.
3. obstruction of small craft navigation in confined waters.
4. encroachment of emergent and submergent vegetation on swimming beaches.

With respect to 1), while three commercial fishermen hold licenses in Ontario waters of Lake St. Francis, no active fishing is now carried out reportedly due to the above mentioned factors but due also, in part,

to tainting of fish flesh and related marketing problems. In connection with the latter, a study was carried out in 1964 by this Branch in co-operation with the Department of Lands and Forests in which taste tests revealed adverse flavours in various commercial species related to Kraft mill discharges from Domtar Pulp and Paper Limited.

In nearly all interviews and reports received from the public, concern was expressed over marked increases in abundance of aquatic vegetation since completion of the seaway development in 1959. It was the contention of most people interviewed that diversion of flows away from the north shore of the lake by control dams at Cornwall and Massena, has contributed to this increase. However, information provided by the St. Lawrence Seaway Authority indicated no major alterations in flow patterns below Cornwall. It is possible that one or both of the following factors are significant:

1. Wet and dry dredging operations during the period of Seaway construction and newly flooded areas of Lake St. Lawrence may have substantially increased sediment and nutrient contributions to Lake St. Francis.
2. Control works at Cornwall have reduced seasonal fluctuations in discharges to Lake St. Francis and may have significantly reduced scouring effects during former periods of peak flows.

The excessive production of aquatic vegetation and advanced state of eutrophication of upper Lake

St. Francis have probably been largely due to physical and other natural factors. However, major sources of added enrichment, notably sanitary wastes from Cornwall and discharges from the Domtar mill and perhaps other upstream industries, have undoubtedly greatly accelerated natural processes.

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